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EFFECT OF 5.56 MM PRIMER COMPONENTS ON BALLISTIC PERFORMANCE OF THE M16A1 RIFLE/AMMUNITION SYSTEM

Margaret E. Brown

Frankford Arsenal
Philadelphia, Pennsylvania

October 1972

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DEPARTMENT OF THE ARMY
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

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The results of this test show that within the limits tested, primer components did effect ballistic performance, but to a lesser degree than external factors such as the rifle used and the conditioning temperature of the ammunition. In particular, the inherent differences in cyclic rate performance of the two rifles used in the ball portion of the test were so great that they masked the effects of primers on cyclic rate.

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As a result of previous testing at Frankford Arsenal, it was decided to conduct more extensive testing of 5.56 mm primers. A factorially designed experiment was conducted to determine the effects of these primers on interior ballistics for both ball and tracer ammunition. The primer mixture, the primer weight, and the conditioning temperature of the ammunition were varied to investigate their effects, individually and in conjunction with each other, on the cyclic rate of the M16 rifle, on the action time of the ammunition in the rifle, and on the velocity of the projectile.

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FOREWORD

The contributions and assistance of Doris Stone, Jo Anne Brophy, Theresa Elmendorf, and Dr. E. Inselmann are gratefully acknowledged.

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INTRODUCTION

A previous study of the interaction of 5.56 mm components[1] showed that primers have a statistically significant effect on the cyclic rate of the M16 rifle. The same study also suggested an interdependence of cyclic rate of the rifle, velocity of the ammunition fired in the rifle, and action time of the ammunition.

Possible optimization of the primer for 5.56 mm ammunition dictated further investigation of the effects of primers on the ballistics of ammunition and on the rate of fire of the rifle. Of primary concern in this investigation are the effects of primer mixture, primer pellet weight, conditioning temperature of ammunition, and any interaction among these three factors on the following parameters:

1. Cyclic rate of the rifle,
2. Action time of ammunition in gun,
3. Velocity of ammunition fired from rifle.

TEST PLAN

Factorial investigation of primer function in 5.56 mm ammunition divides itself naturally into two parts: (1) M193 ball cartridges with WC846 ball propellant; (2) M196 tracer cartridges with IMR8208M extruded propellant. Each part of the study involves the same three primer mixes, two primer pellet weights, and three conditioning temperatures in all possible combinations.

The six possible combinations of primer mixtures and pellet weights are identified as S, SS, IC, ICC, IID, and IIDD. Primers with combinations designated as IC, ICC, IID, and IIDD are from primer lots used in an interface study[2] between primers and propellants. S and SS are composed of standard FA #41 mix.

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[1]M.E. Brown, "Interaction Study of 5.56 mm Components," unpublished Frankford Arsenal report.

[2]W.H. Squire and M.P. Devine, "The Interface between Primer and Propellant, Parts I and II," American Ordnance Association Paper, presented at Frankford Arsenal, 4-5 June 1969.

The single letters (S, C, D) indicate standard pellet weight and the double letters (SS, CC, DD) signify reduced pellet weight. The standard pellet weight for primers is .410 - .430 grains; the reduced pellet weight is .300 - .340 grains.

The composition of each primer mix is presented in Table I.

TABLE I.
Primer Composition

Components	Mix (%) IC	IID	S
Normal Lead Styphnate	41	39	37
Barium Nitrate	45	38	32
Aluminum	10	15	7
Tetracene	4	4	4
PETN	-	4	5
Antimony Sulfide	-	-	15

The three conditioning temperatures for ammunition are +140° F, +70° F, and -40° F.

For use in analysis, the components are numerically coded as shown in Table II.

TABLE II.
Factors Identification

Mixture		Pellet Weight		Temperature	
S	1	Standard	1	+140° F	1
I	2	Light	2	+70° F	2
II	3			-40° F	3

Experimental test samples are composed of all possible combinations of the three factors and are identified by an ordered triplet in which the first digit refers to mixture level, the second refers to pellet weight level, and the third refers to conditioning temperature level. Thus, we have the following test samples:

111	121	211	221	311	321
112	122	212	222	312	322
113	123	213	223	313	323

In particular, sample 213 has a primer of mix "I," a standard pellet weight, and was conditioned at -40° F before firing.

For tracer ammunition where the rifle is an added two level factor, the fourth digit of each ordered group of numbers designates the level of the gun. Consequently, the samples are identified as follows:

1111	1211	2111	2211	3111	3211
1112	1212	2112	2212	3112	3212
1121	1221	2121	2221	3121	3221
1122	1222	2122	2222	3122	3222
1131	1231	2131	2231	3131	3231
1132	1232	2132	2232	3132	3232

Charge development to meet the ballistic requirements of Military Specifications[3] assures practical application of results.

DETAILS OF TEST

Charge Development

The primers chosen for this interaction investigation are members of a large group of primers that were used in a primer and propellant interface study.[2] Table III shows average velocities and average maximum pressures of pressure-time curves obtained from the

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[2]W. H. Squire and M. P. Devine, "The Interface between Primer and Propellant, Parts I and II," American Ordnance Association Paper, presented at Frankford Arsenal, 4-5 June 1969.

[3]MIL-C-9963D; Military Specification, Cartridge 5.56mm: Ball, M193.
MIL-C-6011A; Military Specification, Cartridge 5.56mm: Tracer, M196.

interface study; Table IV shows the results of charge development for M193 ball rounds and M196 tracer rounds.

In the interface study, rounds with IIDD primers yielded much higher peak pressures but only slightly higher velocities than rounds with IID primers when both groups of rounds were loaded with the same charge (28.0 grains of WC846 propellants). This phenomenon was common for most ammunition having primers of type II mix or type S mix. In charge development for this investigation, ball rounds with type IIDD primers required a lesser charge weight of WC846 propellant than those with type IID primers to produce comparative pressures and velocities.

Direct comparison of velocities and pressures in the two studies is not possible. Velocities reported in charge development were taken in velocity test barrels and corrected to level of reference ammunition fired at the same time. Recorded pressures are copper pressure taken in pressure test barrels and corrected to level of reference rounds fired at the same time. On the other hand, in the interface study both velocities and maximum chamber pressures (from pressure-time curves) are recorded as obtained in a pressure test barrel.

Note that, in general, the ball rounds using primers with lower pellet weights require a lesser charge weight than those with higher pellet weights, while tracer rounds with lower pellet weight primers require a greater charge weight. Tracer velocities are lower than ball velocities since military standards[3] call for 3250 ± 40 ft/sec for ball rounds and for 3200 ± 40 ft/sec for tracers at 15 ft from the muzzle of the gun.

TABLE III.
Results from Interface Study

Primer Type	Charge Weight WC846 (grains)	Average Velocity* in Pressure Barrel (ft/sec)	Average Maximum Chamber Pressure from P-T Curves (kpsi)
IC	28.0	3255	51.8
ICC	28.0	3283	52.4
IID	28.0	3164	47.2
IIDD	28.0	3193	57.0

*Velocity at 15 feet from muzzle of gun.

[3] MIL-C-9963D; Military Specification, Cartridge 5.56mm: Ball, M193. MIL-C-6011A; Military Specification, Cartridge 5.56mm: Tracer, M196.

TABLE IV.
Results for Charge Development

Primer Type	Velocity Test Barrel: Charge Weight (grains)	Velocity Test Barrel: Average Velocity* (ft/sec)	Pressure Barrel: Copper Chamber (kpsi)	Pressure Barrel: Copper Port (kpsi)	Pressure Barrel: Average Velocity* (ft/sec)	Barrel Number
Ball Rounds with WC846 Propellant, Lot 44571						
S	28.0	3235	46.5	14.9	3198	G22
SS	28.0	3237	44.4	14.3	3147	G29
IC	27.8	3251	47.4	15.3	3216	G32
ICC	27.6	3256	48.5	14.6	3211	G22
IID	27.9	3237	48.9	14.4	3230	G32
IIDD	27.5	3235	50.0	14.3	3223	G30
Tracer Rounds with IMR 8208M Propellant, AL45094						
S	25.2	3223	52.2	13.7	3159	G30
SS	25.5	3212	50.1	14.1	3151	G29
IC	25.3	3212	50.8	14.5	3181	G32
ICC	25.7	3220	48.0	13.9	3170	G32
IID	25.4	3221	50.2	14.5	3171	G32
IIDD	25.7	3210	48.6	14.1	3144	G29

*Velocity at 15 feet from muzzle of gun.

Test Procedure

The two M16 rifles selected to conduct the factorial test yielded approximately the same cyclic rate for 5.56 mm ammunition, lot LCSP462 (ball rounds with IMR8208M propellant).

A high-speed chronograph recorded barrel action time and projectile time of flight over a premeasured base line for the individual rounds fired in 20 round bursts. The chronograph count for action time was initiated by the contact of a hammer spring with a ball plunger and terminated by an ionization gage at the muzzle end of the barrel. This is not true action time since contact of hammer spring and ball plunger did not necessarily occur as the firing pin struck the primer. Passage of the projectile through lumiline screens at the beginning and the end of the base line respectively started and stopped the chronograph count for the time of flight. A preset counter recorded the time to fire 19 rounds of the 20 round burst. The contact of the hammer spring (the same one used to initiate action time) with the ball plunger started the preset counter and the twentieth contact stopped the preset counter.

The ball factorial test included two replications, one fired in each of the two rifles. The firing order of all test lots was randomized in each replication. All ammunition was conditioned at the designated temperatures for at least four hours before the start of firing. The rifle was at room temperature and a fouling burst of three rounds (conditioned at +70° F) was fired immediately before firing each 20 round burst for record. Since the method of measuring rifle cycle time does not include the last round of the burst, data for this round is not included in the analyses. A substitute burst was fired for bursts missing any of the 39 data points (cycle time, 19 velocities, and 19 action times).

Aluminum foil screens replaced lumiline screens for the tracer firing since light from the tracer bullet interferred with the functioning of the lumiline screens. The close clustering of shots in a single burst necessitated moving the foil screens down the range to insure obtaining all velocities. The hammer spring setting used to initiate action time measurements for tracer ammunition was different from the setting for ball ammunition.

Spasmodic non-functioning of the rifles during tracer test firing caused doubts concerning the validity of any interpretation of the results. Two rifles, selected because they yielded high and comparable cyclic rate when used with ball reference ammunition, were used to obtain data to replace the questionable data. Since previous tests, both ball and tracer, indicated that the rifle had a greater effect on cyclic time than any other factor under consideration, the rifle was introduced as a two-level factor in the substitute firing.

The order of firings was not completely randomized for the rifles, since constant changing of the rifle in mount was more likely to introduce errors than lack of randomization.

TEST RESULTS AND DISCUSSION

Computer Output and Observations

In order to facilitate the multivariant analysis of cyclic time, action time, and projectile flight time over 20 round bursts, a generalized computer program[4] was modified. The input and output data of this program are listed in the Appendix.

The input data for the tracer portion of the test are the accumulated times for the first 19 rounds of a 20 round burst of ammunition. This data is recorded as:

$Y_1, \quad Y_2, \quad Y_3, \quad ijkm$

where Y_1 is the cyclic time of the rifle; Y_2 is the action time of the ammunition in the rifle; Y_3 is the flight time of the projectile over a 20 foot base line centered at 113 feet from the muzzle of the gun. The ijkm identifies the ammunition used: i is the level of mixture; j is the level of pellet weight; k is the level of conditioning temperature; and m is the level of gun.

Printed in order are the input data along with mean and variance for each treatment combination, the error matrix, and the estimation of parameters. Then printed for each factor and for each first-order interaction of the factors are the design contrast matrix, the sum of products, the univariate F values with degrees of freedom, and the significance levels.

The error matrix, common for all factors and interactions, along with the sum of products for each factor or each interaction is used to compute F values.* In the estimate of parameters, the mean for each

*$F_i = (SH_{ii}/s)/(SE_{ii}/e)$ where the SH_{ii}'s are diagonal elements of the sum of products matrix; SE_{ii}'s are diagonal elements of the error matrix; s is degrees of freedom for the factor or the interaction under consideration; and e is degrees of freedom for error term.

[4]C.F. Starmer and J.E. Grizzle, "A Computer Program for Analysis of Data by General Linear Models," Institute of Statistics Mineo Series No. 560, February 1968.

level of factors or interaction is obtained by algebraically adding the printed values to the grand mean, MU.

The design constrast matrix indicates which factor or which interaction is being considered. The significance levels are the probabilities of making a Type I error (rejection of hypothesis that is actually true) in assuming that there is no significant effect due to the factor tested.

Since the rifle was not considered as a factor for the ball test, our line of input data is:

$$Y_1, \quad Y_2, \quad Y_3, \quad ijk$$

The accumulated flight time of 19 rounds was taken over a 15 foot base line centered at 30.5 feet from the muzzle of the gun.

For easy reference, a summary of F values and the significance level of each such value is presented in Table V. For a more detailed breakdown of the analyses refer to the Appendix.

At an .05 significance level (rejecting the null hypothesis* if this level is equal to or less than .05), the primer mixture in the tracer ammunition does not have a statistically significant mixture effect on cycle time. This time, however, is affected by the other three factors and also by an interaction between pellet weight and temperature. All four factors as well as mixture-temperature and pellet weight-temperature interactions affect action time. The rifle or the interaction of the rifle with any other factors has no effect on flight time. All other factors and all first-order interaction, except interaction between mixture and pellet weight, between these other factors do affect flight time.

For ball ammunition, cycle time is not affected significantly by the three factors considered or by any interaction between pairs of them. (Most likely this statement would be reversed if the planned test had included the rifle as a factor). Pellet weight and temperature has a significant effect on action time. All factors and all first-order interaction excepting mixture-temperature interaction have an effect on flight time.

*Null hypothesis is the hypothesis that there is no significant difference due to the factor being tested.

TABLE V.
Summary

Source	DF	Cyclic Time F	Cyclic Time Significance Level	Action Time F	Action Time Significance Level	Flight Time F	Flight Time Significance Level
Tracer							
Mixture (A)	2	2.34	.10	7.44	.0018	5.25	.0085
Pellet Weight (B)	1	26.63	.0001	476.69	.0001	30.05	.0001
Conditioning Temperature (C)	2	28.98	.0001	338.05	.0001	855.07	.0001
Rifle (D)	1	298.23	.0001	36.03	.0001	0.10	.75
AxB Interaction	2	1.13	.33	2.33	.11	0.04	.97
AxC Interaction	4	1.86	.13	6.63	.0004	6.95	.0003
AxD Interaction	2	0.52	.60	0.10	.91	0.12	.88
BxC Interaction	2	3.90	.03	12.95	.0001	28.69	.0001
BxD Interaction	1	0.02	.88	3.15	.08	0.86	.64
CxD Interaction	2	1.83	.17	0.82	.55	1.57	.22
Error	52						
Total	71						
Ball							
Mixture (A)	2	1.61	.22	0.26	.78	19.25	.0001
Pellet Weight (B)	1	0.34	.57	55.92	.0001	86.84	.0001
Conditioning Temperature (C)	2	2.87	.08	15.87	.0001	112.24	.0001
AxB Interaction	2	0.41	.67	0.25	.78	7.77	.003
AxC Interaction	4	0.20	.93	0.96	.55	2.30	.09
BxC	2	0.58	.58	0.80	.53	86.17	.0001

The ball data averaged according to the rifle used* is:

	Cyclic Time	Action Time	Flight Time
D	.5148-01	.789-04	.1115-03
D reduced	-.5148-01	-.789-04	-.1115-03

Tables of maximum differences between level effects of factors constructed from the above data and from the computer output are shown in Table VI. In both tests, the rifle had a decidedly greater effect on cyclic time and decidedly less effect on flight time than any other factor considered. With the exception of the rifle on cyclic time and the effect of pellet weight on action time, ammunition conditioning temperature had the greatest effect of all factors on the ballistic parameters. Note that conditioning temperature applies to ammunition only and not to the rifle and/or environment as would be experienced in practice.

TABLE VI.
Maximum Difference in Level Effect of Factors

Factor	Cyclic Time	Action Time	Flight Time
	Tracer		
A (mixture)	.0269	.000228	.000762
B (pellet weight)	.0523	.001180	.001061
C (temperature)	.0843	.001557	.009716
D (rifle)	.1753	.000324	.000061
	Ball		
A (mixture)	.0488	.000175	.000681
B (pellet weight)	.0134	.001496	.000855
C (temperature)	.0642	.001290	.001682
D (rifle)	.1030	.000158	.000233

*The input data for the two rifles is presented alternately in the beginning of the ball portion of computer listing in the Appendix.

Variations in Cycle Time of Rifles

Original plans called for using the same two rifles, designated as #3 and #6, for both the ball and the tracer ammunition. Ball test firing proceeded smoothly, but frequent stoppages interferred with tracer firing. Complete data was obtained for rifle #6 after a few replacement firings, but not for rifle #3. The "panama gun," a worn-out rifle with a short cyclic time was previously used to check out the functioning of the measuring equipment, now it was used to check the ability of this tracer ammunition to function a rifle. No problems were encountered in this check. Two rifles, #867083 and #848921 were selected, then, to replace #3 and #6 for the tracer test.

No direct comparison of action time or flight time data between the two groups of rifles is possible. The base line for rifle #6 and the panama gun, centered at 98 feet, was 8.958 feet long. For the other two rifles, the base line, centered at 113 feet, was 20 feet long. For rifle #6 and the panama gun, the initiating hammer spring for action time was set to strike the ball plunger at approximately the same time as the firing pin struck the primer and thus the recorded action time was close to true action time. For the other two rifles, the earlier contact of the initiating spring with the ball plunger resulted in a recorded action time somewhat greater than the actual time.

Keeping the above differences in mind, a comparison of the results of firing in the four guns is presented in Table VII. Times averaged over all ammunition lots are the sum of times in seconds of the first 19 rounds of a 20 round burst. Of particular interest is that change in action time, due to rifle, seems to have considerable influence on cyclic rate but only slight, if any, influence on flight time.

TABLE VII.
Summary of Firing Results

Rifle No.	Cyclic Time (seconds)	Action Time (seconds)	Flight Time (seconds)
865083	1.6082	.03872*	.12846
848921	1.6328	.03904*	.12840
6	1.8568	.02764	.05611
Panama gun	1.4991	.03225	.05683

*Sum of true action time plus an unknown constant.

Table VIII shows cyclic times and flight times of Table VII converted to the more familiarly recognized cyclic rates and velocities. From this data, one can see the importance of considering the rifle in determining cyclic rate differences due to ammunition variations.

TABLE VIII.
Summary of Cyclic Rates and Velocities

Rifle No.	Cyclic Rate (rounds/minute)	Velocity (feet/second)
865083	630	2958*
848921	698	2960*
6	614	3033**
Panama gun	760	2995**

*Velocity at 113 feet from muzzle of gun.
**Velocity at 98 feet from muzzle of gun.

CONCLUSIONS

Within the limits tested, external factors, namely rifle and conditioning temperature of the ammunition, have greater influence than the primer on ballistic parameters. Cyclic time of the M16 rifle is a function mainly of the rifle itself, but the flight time of the 5.56 mm projectile depends mostly on conditioning temperature and then on the pellet weight of the primer. Reduced primer pellet weight with IMR propellant decreases cyclic time (increases cyclic rate) with little or no effect on velocity.

Increasing action time tends to increase flight time for both ball and tracer ammunition. In case of tracer ammunition, increasing action time tends to decrease cyclic time. Action time of ball ammunition has negligible effect on cyclic time.

RECOMMENDATIONS

1. If modification of the 5.56 mm primer is considered for any reason, the effect of primer pellet weight on ballistic parameters should be taken into account. In particular, reduced pellet weight should be considered for use with IMR propellant.

2. Any future study of the effects of 5.56 mm ammunition or its components on cyclic rate should take into consideration the effects of the rifle.

APPENDIX
Multivariate Analysis

M196, 5.56 mm, TRACER

Input

```
     ANALYSIS OF MULTIVARIATE GENERAL LINEAR MODELS
               LIST OF CONTROL PARAMETER
      NUMBER OF MAIN EFFECTS =     4
      NUMBER OF DEPENDENT VARIABLES =     3
      NUMBER OF 2-FACTOR INTERACTIONS =     6
 NME =     4  LEVEL =     3    2    3    2
 NIT =     6  INT =     1    2    1    3    1    4    2    3    2    4    3    4


MEANS AND VARIANCES ARE CORRECT ONLY IF THE DATA ARE SORTED BY CELL


 1.863000   .037786   .124600    1    1    1    1
 1.896000   .037974   .125033    1    1    1    1

N =     2    MEANS AND VARIANCES FOR CELL    1  1  1  1

   MEAN        .18795000E+01      .37880000E-01      .12481650E+00

VARIANCE       .54450000E-03      .17672000E-07      .93744500E-07


 1.673000   .037956   .124852    1    1    1    2
 1.705000   .038092   .125190    1    1    1    2

N =     2    MEANS AND VARIANCES FOR CELL    1  1  1  2

   MEAN        .16890000E+01      .38024000E-01      .12502100E+00

VARIANCE       .51200000E-03      .92480000E-08      .57122000E-07


 1.818000   .037771   .126704    1    1    2    1
 1.894000   .037619   .127363    1    1    2    1

N =     2    MEANS AND VARIANCES FOR CELL    1  1  2  1

   MEAN        .18560000E+01      .37695000E-01      .12703350E+00

VARIANCE       .28880000E-02      .11552000E-07      .21714050E-06
```

```
 1.626000   .038035   .126618    1    1    2    2
 1.629000   .038009   .127064    1    1    2    2

N =      2   MEANS AND VARIANCES FOR CELL    1  1  2  2

   MEAN        .16275000E+01        .38022000E-01        .12684100E+00

VARIANCE       .45000000E-05        .33800000E-09        .99458000E-07


 1.784000   .038379   .130497    1    1    3    1
 1.906000   .038373   .130805    1    1    3    1

N =      2   MEANS AND VARIANCES FOR CELL    1  1  3  1

   MEAN        .18450000E+01        .38376000E-01        .13065100E+00

VARIANCE       .74420000E-02        .17999990E-10        .47432000E-07


 1.784000   .039013   .129177    1    1    3    2
 1.649000   .038730   .131634    1    1    3    2

N =      2   MEANS AND VARIANCES FOR CELL    1  1  3  2

   MEAN        .17165000E+01        .38871500E-01        .13040550E+00

VARIANCE       .91125000E-02        .40044500E-07        .30184245E-05


 1.780000   .038561   .123073    1    2    1    1
 1.931000   .038606   .124284    1    2    1    1

N =      2   MEANS AND VARIANCES FOR CELL    1  2  1  1

   MEAN        .18555000E+01        .38583500E-01        .12367850E+00

VARIANCE       .11400500E-01        .10125000E-08        .73326050E-06


 1.642000   .039055   .123067    1    2    1    2
 1.677000   .038663   .124406    1    2    1    2

N =      2   MEANS AND VARIANCES FOR CELL    1  2  1  2

   MEAN        .16595000E+01        .38859000E-01        .12373650E+00

VARIANCE       .61250000E-03        .76832000E-07        .89646050E-06
```

```
 1.760000   .038974   .127807    1    2    2    1
 1.741000   .039151   .128136    1    2    2    1

N =     2   MEANS AND VARIANCES FOR CELL    1  2  2  1

   MEAN        .17505000E+01       .39062500E-01       .12797150E+00

VARIANCE       .18050000E-03       .15664500E-07       .54120500E-07


 1.571000   .039325   .127732    1    2    2    2
 1.590000   .039283   .128194    1    2    2    2

N =     2   MEANS AND VARIANCES FOR CELL    1  2  2  2

   MEAN        .15805000E+01       .39304000E-01       .12796300E+00

VARIANCE       .18050000E-03       .88200000E-09       .10672200E-06


 1.703000   .040098   .134130    1    2    3    1
 1.782000   .040173   .134829    1    2    3    1

N =     2   MEANS AND VARIANCES FOR CELL    1  2  3  1

   MEAN        .17425000E+01       .40135500E-01       .13447950E+00

VARIANCE       .31205000E-02       .28125000E-08       .24430050E-06


 1.654000   .040704   .131878    1    2    3    2
 1.568000   .040868   .135477    1    2    3    2

N =     2   MEANS AND VARIANCES FOR CELL    1  2  3  2

   MEAN        .16110000E+01       .40786000E-01       .13367750E+00

VARIANCE       .36980000E-02       .13448000E-07       .64764005E-05


 1.865000   .037977   .123895    2    1    1    1
 1.843000   .037615   .124357    2    1    1    1

N =     2   MEANS AND VARIANCES FOR CELL    2  1  1  1

   MEAN        .18540000E+01       .37796000E-01       .12412600E+00

VARIANCE       .24200000E-03       .65522000E-07       .10672200E-06
```

```
 1.679000   .037926   .124388    2    1    1    2
 1.684000   .037770   .124793    2    1    1    2

N =      2    MEANS AND VARIANCES FOR CELL     2  1  1  2

   MEAN         .16815000E+01        .37848000E-01        .12459050E+00

VARIANCE        .12500000E-04        .12168000E-07        .82012500E-07


 1.769000   .038100   .126834    2    1    2    1
 1.765000   .038105   .127753    2    1    2    1

N =      2    MEANS AND VARIANCES FOR CELL     2  1  2  1

   MEAN         .17670000E+01        .38102500E-01        .12729350E+00

VARIANCE        .80000000E-05        .12500015E-10        .42228050E-06


 1.596000   .038067   .127455    2    1    2    2
 1.683000   .038087   .127221    2    1    2    2

N =      2    MEANS AND VARIANCES FOR CELL     2  1  2  2

   MEAN         .16395000E+01        .38077000E-01        .12733800E+00

VARIANCE        .37845000E-02        .20000002E-09        .27378000E-07


 1.795000   .039666   .134896    2    1    3    1
 1.761000   .038654   .132560    2    1    3    1

N =      2    MEANS AND VARIANCES FOR CELL     2  1  3  1

   MEAN         .17780000E+01        .39160000E-01        .13372800E+00

VARIANCE        .57800000E-03        .51207200E-06        .27284480E-05


 1.639000   .039859   .131411    2    1    3    2
 1.604000   .039290   .133874    2    1    3    2

N =      2    MEANS AND VARIANCES FOR CELL     2  1  3  2

   MEAN         .16215000E+01        .39574590E-01        .13264250E+00

VARIANCE        .61250000E-03        .16188050E-06        .30331845E-05
```

```
 1.870000   .038714   .122462    2    2    1    1
 1.860000   .038241   .123839    2    2    1    1

N =      2   MEANS AND VARIANCES FOR CELL    2  2  1  1

   MEAN       .18650000E+01       .38477500E-01       .12315050E+00

VARIANCE      .50000000E-04       .11186450E-06       .94806450E-06


 1.648000   .038888   .123063    2    2    1    2
 1.664000   .039016   .124542    2    2    1    2

N =      2   MEANS AND VARIANCES FOR CELL    2  2  1  2

   MEAN       .16560000E+01       .38952000E-01       .12380250E+00

VARIANCE      .12800000E-03       .81920000E-08       .10937205E-05


 1.786000   .039020   .127523    2    2    2    1
 1.786000   .039027   .128546    2    2    2    1

N =      2   MEANS AND VARIANCES FOR CELL    2  2  2  1

   MEAN       .17860000E+01       .39023500E-01       .12803450E+00

VARIANCE     0.                   .24499999E-10       .52326450E-06


 1.580000   .039414   .128725    2    2    2    2
 1.599000   .039615   .128697    2    2    2    2

N =      2   MEANS AND VARIANCES FOR CELL    2  2  2  2

   MEAN       .15895000E+01       .39514500E-01       .12871100E+00

VARIANCE      .18050000E-03       .20200500E-07       .39199999E-09


 1.647000   .040908   .135989    2    2    3    1
 1.723000   .040507   .136363    2    2    3    1

N =      2   MEANS AND VARIANCES FOR CELL    2  2  3  1

   MEAN       .16850000E+01       .40707500E-01       .13617600E+00

VARIANCE      .28880000E-02       .80400500E-07       .69938000E-07
```

```
 1.556000   .041065   .135393    2    2    3    2
 1.579000   .041121   .136255    2    2    3    2

N =    2   MEANS AND VARIANCES FOR CELL    2  2  3  2

   MEAN       .15675000E+01        .41093000E-01        .13582400E+00

VARIANCE      .26450000E-03        .15680000E-08        .37152200E-06


 1.937000   .037635   .123202    3    1    1    1
 1.846000   .037173   .124272    3    1    1    1

N =    2   MEANS AND VARIANCES FOR CELL    3  1  1  1

   MEAN       .18915000E+01        .37404000E-01        .12373700E+00

VARIANCE      .41405000E-02        .10672200E-06        .57245000E-06


 1.723000   .037868   .124315    3    1    1    2
 1.693000   .037586   .122855    3    1    1    2

N =    2   MEANS AND VARIANCES FOR CELL    3  1  1  2

   MEAN       .17080000E+01        .37727000E-01        .12358500E+00

VARIANCE      .45000000E-03        .39762000E-07        .10658000E-05


 1.779000   .037768   .126459    3    1    2    1
 1.867000   .037916   .127910    3    1    2    1

N =    2   MEANS AND VARIANCES FOR CELL    3  1  2  1

   MEAN       .18230000E+01        .37842000E-01        .12718450E+00

VARIANCE      .38720000E-02        .10952000E-07        .10527005E-05


 1.615000   .038171   .126914    3    1    2    2
 1.621000   .038174   .127624    3    1    2    2

N =    2   MEANS AND VARIANCES FOR CELL    3  1  2  2

   MEAN       .16180000E+01        .38172500E-01        .12726900E+00

VARIANCE      .18000000E-04        .44999976E-11        .25205000E-06
```

```
 1.809000   .039236   .133401    3     1     3     1
 1.835000   .039420   .133857    3     1     3     1

N =     2   MEANS AND VARIANCES FOR CELL     3   1   3   1

    MEAN         .18220000E+01        .39328000E-01        .13362900E+00

VARIANCE         .33800000E-03        .16928000E-07        .10396800E-06


 1.639000   .039384   .131485    3     1     3     2
 1.607000   .039261   .133199    3     1     3     2

N =     2   MEANS AND VARIANCES FOR CELL     3   1   3   2

    MEAN         .16230000E+01        .39322500E-01        .13234200E+00

VARIANCE         .51200000E-03        .75645000E-08        .14688980E-05


 1.764000   .038287   .122928    3     2     1     1
 1.983000   .038279   .124301    3     2     1     1

N =     2   MEANS AND VARIANCES FOR CELL     3   2   1   1

    MEAN         .18735000E+01        .38283000E-01        .12361450E+00

VARIANCE         .23980500E-01        .32000014E-10        .94256450E-06


 1.658000   .038269   .123131    3     2     1     2
 1.718000   .038529   .124030    3     2     1     2

N =     2   MEANS AND VARIANCES FOR CELL     3   2   1   2

    MEAN         .16880000E+01        .38399000E-01        .12358050E+00

VARIANCE         .18000000E-02        .33800000E-07        .40410050E-06


 1.738000   .038841   .127474    3     2     2     1
 1.777000   .038966   .128607    3     2     2     1

N =     2   MEANS AND VARIANCES FOR CELL     3   2   2   1

    MEAN         .17575000E+01        .38903500E-01        .12804050E+00

VARIANCE         .76050000E-03        .78125000E-08        .64184450E-06
```

```
  1.539000   .039728   .128322    3    2    2    2
  1.567000   .039504   .128519    3    2    2    2

 N =      2   MEANS AND VARIANCES FOR CELL    3  2  2  2

    MEAN       .15530000E+01       .39616000E-01       .12842050E+00

VARIANCE       .39200000E-03       .25088000E-07       .19404500E-07


  1.692000   .039843   .134135    3    2    3    1
  1.739000   .040478   .135842    3    2    3    1

 N =      2   MEANS AND VARIANCES FOR CELL    3  2  3  1

    MEAN       .17155000E+01       .40160500E-01       .13498850E+00

VARIANCE       .11045000E-02       .20161250E-06       .14569245E-05


  1.559000   .040919   .135128    3    2    3    2
  1.564000   .040273   .135843    3    2    3    2

 N =      2   MEANS AND VARIANCES FOR CELL    3  2  3  2

    MEAN       .15615000E+01       .40596000E-01       .13548550E+00

VARIANCE       .12500000E-04       .20865800E-06       .25561250E-06
```

Output

ERROR MATRIX

.964842E-01	.599359E-04	.162949E-03
.599359E-04	.273249E-05	.155329E-05
.162949E-03	.155329E-05	.350721E-04

ESTIMATES OF PARAMETERS =B

MU		.172050E+01	.388800E-01	.128432E+00
A	1	.139167E-01	-.800556E-04	-.409542E-03
A	2	-.129583E-01	.147194E-03	.352292E-03
REDUCED		-.958333E-03	-.671389E-04	.572500E-04
B	1	.261944E-01	-.589833E-03	-.530597E-03
REDUCED		-.261944E-01	.589833E-03	.530597E-03
C	1	.545833E-01	-.693889E-03	-.447921E-02
C	2	-.248333E-01	-.268722E-03	-.757417E-03
REDUCED		-.297500E-01	.962611E-03	.523663E-02
D	1	.876667E-01	-.162167E-03	.304861E-04
REDUCED		-.876667E-01	.162167E-03	-.304861E-04
INTERACT	1	.830556E-02	-.653333E-04	-.309028E-04
INTERACT	2	-.101528E-01	-.110000E-04	.322639E-04
INTERACT	1	-.181250E-01	.230597E-03	.769417E-03
INTERACT	2	-.595833E-02	-.103194E-04	.186750E-03
INTERACT	3	.200000E-02	-.649028E-04	-.388167E-03
INTERACT	4	.127917E-01	-.790694E-04	-.183083E-03
INTERACT	1	-.583333E-03	-.156667E-04	.516806E-04
INTERACT	2	-.604167E-02	.128333E-04	-.638194E-04
INTERACT	1	-.173611E-01	.183583E-03	.890014E-03
INTERACT	2	-.277778E-04	-.362500E-04	.154722E-04
INTERACT	1	.750000E-03	.479722E-04	.897639E-04
INTERACT	1	.708333E-02	.467500E-04	-.129903E-03
INTERACT	2	.666667E-02	-.109167E-04	-.112528E-03

```
                                      DESIGN CONTRAST MATRIX = C
0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                        SUM OF PRODUCTS DUE TO HO =SH
                                   .8700250E-02   -.7097183E-04   -.2476664E-03
                                  -.7097183E-04    .7819854E-06    .1939146E-05
                                  -.2476664E-03    .1939146E-05    .7082673E-05

                          UNIVARIATE F VALUES WITH       ,     52  DEGREES OF FREEDOM

                                2.3445       7.4407       5.2506

                                            SIGNIFICANCE LEVELS

                                 .1040        .0018        .0085


                                      DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                        SUM OF PRODUCTS DUE TO HO =SH
                                   .4940272E-01   -.1112426E-02   -.1000706E-02
                                  -.1112426E-02    .2504904E-04    .2253340E-04
                                  -.1000706E-02    .2253340E-04    .2027041E-04

                          UNIVARIATE F VALUES WITH    1 ,     52  DEGREES OF FREEDOM

                               26.6255    476.6894      30.0541

                                            SIGNIFICANCE LEVELS

                                 .0001        .0001        .0001

                                      DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                        SUM OF PRODUCTS DUE TO HO =SH
                                   .1075463E+00   -.1436140E-02   -.9155293E-02
                                  -.1436140E-02    .3552753E-04    .2004586E-03
                                  -.9155293E-02    .2004586E-03    .1153421E-02

                          UNIVARIATE F VALUES WITH    2 ,     52  DEGREES OF FREEDOM

                               28.9810    338.0488     855.0657

                                            SIGNIFICANCE LEVELS

                                 .0001        .0001        .0001
```

```
                                              DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                               SUM OF PRODUCTS DUE TO HO =SH
                                           .5533520E+00   -.1023596E-02    .1924283E-03
                                          -.1023596E-02    .1893458E-05   -.3559558E-06
                                           .1924283E-03   -.3559558E-06    .6691701E-07

                                  UNIVARIATE F VALUES WITH    1 ,    52  DEGREES OF FREEDOM

                                        298.2281      36.0330       .0992

                                                SIGNIFICANCE LEVELS

                                           .0001        .0001       .7523


                                              DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                               SUM OF PRODUCTS DUE TO HO =SH
                                           .4211361E-02   -.6958667E-05   -.1408193E-04
                                          -.6958667E-05    .2451893E-06    .3744433E-07
                                          -.1408193E-04    .3744433E-07    .4794703E-07

                                  UNIVARIATE F VALUES WITH    2 ,    52  DEGREES OF FREEDOM

                                          1.1349       2.3330       .0355

                                                SIGNIFICANCE LEVELS

                                           .3297        .1052       .9655


                                              DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                               SUM OF PRODUCTS DUE TO HO =SH
                                           .1378792E-01   -.1334847E-03   -.4748257E-03
                                          -.1334847E-03    .1394110E-05    .4801988E-05
                                          -.4748257E-03    .4801988E-05    .1876142E-04

                                  UNIVARIATE F VALUES WITH    4 ,    52  DEGREES OF FREEDOM

                                          1.8577       6.6326      6.9542

                                                SIGNIFICANCE LEVELS

                                           .1310        .0004       .0003
```

DESIGN CONTRAST MATRIX - [illegible]

[illegible]

[illegible]

SUM OF PRODUCTS DUE TO HO-HA

[illegible]

UNIVARIATE F VALUES WITH [illegible] , 52 DEGREES OF FREEDOM

[illegible]

SIGNIFICANCE LEVELS

[illegible]

DESIGN CONTRAST MATRIX - [illegible]

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0

SUM OF PRODUCTS DUE TO HO-HA

.1668278E-01	-.1379668E-03	-.7687398E-03
-.1379668E-03	.1361376E-05	.7126739E-05
-.7687398E-03	.7126739E-05	.3866660E-04

UNIVARIATE F VALUES WITH 2 , 52 DEGREES OF FREEDOM

3.9068 12.9537 28.6896

SIGNIFICANCE LEVELS

.0256 .0001 .0001

DESIGN CONTRAST MATRIX - C

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0

SUM OF PRODUCTS DUE TO HO-HA

.6050000E-06	.2560500E-05	.6067250E-05
.2560500E-05	.1056061E-06	.3100645E-06
.6067250E-05	.3100645E-06	.5801660E-06

UNIVARIATE F VALUES WITH 1 , 52 DEGREES OF FREEDOM

.0210 3.1532 .6602

SIGNIFICANCE LEVELS

.8778 .0780 .4191

```
                                        DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0


                                    SUM OF PRODUCTS DUE TO HO =SH
                                 .6800333E-02    .1802583E-04   -.1200900E-03
                                 .1802583E-04    .8613033E-07   -.3247589E-06
                                -.1200900E-03   -.3247589E-06    .2119435E-05

                       UNIVARIATE F VALUES WITH    2 ,    52  DEGREES OF FREEDOM

                              1.8347       .0195       1.5712

                                       SIGNIFICANCE LEVELS

                               .1800       .5502        .2160
```

M193, 5.56 mm BALL

Input

```
ANALYSIS OF MULTIVARIATE GENERAL LINEAR MODELS
LIST OF CONTROL PARAMETER
NUMBER OF MAIN EFFECTS =      3
NUMBER OF DEPENDENT VARIABLES =      3
NUMBER OF 2-FACTOR INTERACTIONS =      3
NME =      3  LEVEL =      3    2    3
NIT =      3  INT =      1    2    1    3    2    3


MEANS AND VARIANCES ARE CORRECT ONLY IF THE DATA ARE SORTED BY CELL


 1.422000   .031573   .090926    1    1    1   -0
 1.340000   .031889   .090878    1    1    1   -0

N =      2   MEANS AND VARIANCES FOR CELL    1  1  1

    MEAN        .13810000E+01       .31731000E-01       .90902000E-01

VARIANCE        .33620000E-02       .49928000E-07       .11520002E-08


 1.434000   .031261   .091612    1    1    2   -0
 1.368000   .031714   .091190    1    1    2   -0

N =      2   MEANS AND VARIANCES FOR CELL    1  1  2

    MEAN        .14010000E+01       .31487500E-01       .91401000E-01

VARIANCE        .21780000E-02       .10260450E-06       .89042000E-07


 1.515000   .034067   .090785    1    1    3   -0
 1.417000   .031762   .090478    1    1    3   -0

N =      2   MEANS AND VARIANCES FOR CELL    1  1  3

    MEAN        .14660000E+01       .32914500E-01       .90631500E-01

VARIANCE        .48020000E-02       .26565125E-05       .47124500E-07
```

```
  1.491000   .032665   .090764    1     2     1    -0
  1.389000   .033158   .090263    1     2     1    -0

 N =      2   MEANS AND VARIANCES FOR CELL     1  2  1

    MEAN          .14400000E+01        .32911500E-01        .90513500E-01

VARIANCE          .52020000E-02        .12152450E-06        .12550050E-06


  1.436000   .032773   .091118    1     2     2    -0
  1.357000   .033353   .091182    1     2     2    -0

 N =      2   MEANS AND VARIANCES FOR CELL     1  2  2

    MEAN          .13965000E+01        .33063000E-01        .91150000E-01

VARIANCE          .31205000E-02        .16820000E-06        .20480000E-08


  1.508000   .035907   .093715    1     2     3    -0
  1.411000   .034021   .092854    1     2     3    -0

 N =      2   MEANS AND VARIANCES FOR CELL     1  2  3

    MEAN          .14595000E+01        .34964000E-01        .93284500E-01

VARIANCE          .47045000E-02        .17784980E-05        .37066050E-06


  1.500000   .031760   .091191    2     1     1    -0
  1.380000   .032334   .091221    2     1     1    -0

 N =      2   MEANS AND VARIANCES FOR CELL     2  1  1

    MEAN          .14400000E+01        .32047000E-01        .91206000E-01

VARIANCE          .72000000E-02        .16473800E-06        .45000015E-09


  1.454000   .032065   .092105    2     1     2    -0
  1.382000   .032348   .091832    2     1     2    -0

 N =      2   MEANS AND VARIANCES FOR CELL     2  1  2

    MEAN          .14180000E+01        .32206500E-01        .91968500E-01

VARIANCE          .25920000E-02        .40044500E-07        .37264500E-07
```

```
 1.537000   .033172   .092357    2     1     3   -0
 1.449000   .032562   .091661    2     1     3   -0

N =      2   MEANS AND VARIANCES FOR CELL     2  1  3

   MEAN         .14930000E+01        .32867000E-01        .92009000E-01

VARIANCE        .38720000E-02        .18605000E-06        .24220800E-06


 1.487000   .032453   .091266    2     2     1   -0
 1.404000   .032974   .090973    2     2     1   -0

N =      2   MEANS AND VARIANCES FOR CELL     2  2  1

   MEAN         .14455000E+01        .32713500E-01        .91119500E-01

VARIANCE        .34445000E-02        .13572050E-06        .42924500E-07


 1.441000   .033303   .091719    2     2     2   -0
 1.365000   .033870   .091808    2     2     2   -0

N =      2   MEANS AND VARIANCES FOR CELL     2  2  2

   MEAN         .14030000E+01        .33586500E-01        .91763500E-01

VARIANCE        .28880000E-02        .16074450E-06        .39604999E-08


 1.476000   .034780   .093807    2     2     3   -0
 1.375000   .034626   .093999    2     2     3   -0

N =      2   MEANS AND VARIANCES FOR CELL     2  2  3

   MEAN         .14255000E+01        .34703000E-01        .93903000E-01

VARIANCE        .51005000E-02        .11858000E-07        .18432000E-07


 1.525000   .031892   .090528    3     1     1   -0
 1.380000   .031690   .090360    3     1     1   -0

N =      2   MEANS AND VARIANCES FOR CELL     3  1  1

   MEAN         .14525000E+01        .31791000E-01        .90444000E-01

VARIANCE        .10512500E-01        .20402000E-07        .14112000E-07
```

```
 1.519000   .031461   .091142    3    1    2   -0
 1.401000   .032016   .091135    3    1    2   -0

N =      2   MEANS AND VARIANCES FOR CELL    3  1  2

   MEAN        .14600000E+01        .31738500E-01        .91138500E-01

VARIANCE       .69620000E-02        .15401250E-06        .24500069E-10


 1.634000   .033570   .091142    3    1    3   -0
 1.469000   .032125   .090755    3    1    3   -0

N =      2   MEANS AND VARIANCES FOR CELL    3  1  3

   MEAN        .15515000E+01        .32847500E-01        .90948500E-01

VARIANCE       .13612500E-01        .10440125E-05        .74884500E-07


 1.484000   .033260   .090486    3    2    1   -0
 1.400000   .033460   .090624    3    2    1   -0

N =      2   MEANS AND VARIANCES FOR CELL    3  2  1

   MEAN        .14420000E+01        .33360000E-01        .90555000E-01

VARIANCE       .35280000E-02        .20000000E-07        .95220001E-08


 1.490000   .033883   .092074    3    2    2   -0
 1.372000   .033702   .091921    3    2    2   -0

N =      2   MEANS AND VARIANCES FOR CELL    3  2  2

   MEAN        .14310000E+01        .33792500E-01        .91997500E-01

VARIANCE       .69620000E-02        .16380500E-07        .11704500E-07


 1.579000   .034297   .094264    3    2    3   -0
 1.420000   .033698   .093858    3    2    3   -0

N =      2   MEANS AND VARIANCES FOR CELL    3  2  3

   MEAN        .14995000E+01        .33997500E-01        .94061000E-01

VARIANCE       .12640500E-01        .17940050E-06        .82418000E-07
```

Output

ERROR MATRIX

.103724E+00	.217826E-03	.226395E-03
.217826E-03	.791987E-05	.136090E-05
.226395E-03	.136090E-05	.166831E-05

ESTIMATES OF PARAMETERS =B

MU		.144475E+01	.329290E-01	.916109E-01
A	1	-.207500E-01	-.837500E-04	-.297167E-03
A	2	-.725000E-02	.915833E-04	.384000E-03
REDUCED		.280000E-01	-.783333E-05	-.868333E-04
B	1	.669444E-02	-.747833E-03	-.427694E-03
REDUCED		-.669444E-02	.747833E-03	.427694E-03
C	1	-.112500E-01	-.503333E-03	-.820917E-03
C	2	-.265000E-01	-.283250E-03	-.410833E-04
REDUCED		.377500E-01	.786583E-03	.862000E-03
INTERACT	1	-.146944E-01	-.530833E-04	.921111E-04
INTERACT	2	.613889E-02	.100750E-03	.160611E-03
INTERACT	1	-.225000E-02	-.206667E-04	.214917E-03
INTERACT	2	.125000E-02	-.286750E-03	.283333E-05
INTERACT	3	.165000E-01	-.137000E-03	-.112500E-04
INTERACT	4	-.500000E-03	.159167E-03	-.878333E-04
INTERACT	1	-.156944E-01	.178500E-03	.488361E-03
INTERACT	2	.138889E-02	-.870833E-04	.360528E-03

```
                                        DESIGN CONTRAST MATRIX = C
0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                          SUM OF PRODUCTS DUE TO HO =SH
                                       .1520550E-01    .10254000E-04    .1141050E-04
                                       .10254000E-04   .18555520E-06    .7208300E-06
                                       .1141050E-04    .7208300E-06     .29196490E-05

                           UNIVARIATE F VALUES WITH    2 ,    22  DEGREES OF FREEDOM

                                   1.6126       .2577     19.2507

                                              SIGNIFICANCE LEVELS

                                    .2209       .7700       .0001


                                        DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                          SUM OF PRODUCTS DUE TO HO =SH
                                       .16133610E-02   -.1002270E-03   -.1030744E-03
                                      -.1002270E-03     .2013317E-04    .1151439E-04
                                      -.1030744E-03     .1151439E-04    .6585211E-05

                           UNIVARIATE F VALUES WITH    1 ,    22  DEGREES OF FREEDOM

                                    .3422     55.9264     86.8393

                                              SIGNIFICANCE LEVELS

                                    .5709       .0001       .0001


                                        DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


                                          SUM OF PRODUCTS DUE TO HO =SH
                                       .2704[illegible]       .5143458E-03    .5143743E-03
                                       .5143458E-03    .1142746E-04    .1323440E-04
                                       .5143743E-03    .1323440E-04    .1702363E-04

                           UNIVARIATE F VALUES WITH    2 ,    22  DEGREES OF FREEDOM

                                   2.8603     15.8717    112.2455

                                              SIGNIFICANCE LEVELS

                                    .0767       .0001       .0001
```

```
                              DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0


                                     SUM OF PRODUCTS DUE TO HO =SH
                                  .3921722E-02    .1188850E-04   -.3035672E-04
                                  .1188850E-04    .1828862E-06    .2800612E-06
                                 -.3035672E-04    .2800612E-06    .1177787E-05

                          UNIVARIATE F VALUES WITH    2 ,    22  DEGREES OF FREEDOM

                                .4159        .2540       7.7657

                                         SIGNIFICANCE LEVELS

                                .6699        .7807        .0031
```

```
                              DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0


                                     SUM OF PRODUCTS DUE TO HO =SH
                                  .3859000E-02   -.3444450E-04    .8774750E-05
                                 -.3444450E-04    .1377024E-05   -.5677832E-06
                                  .8774750E-05   -.5677832E-06    .6962317E-06

                          UNIVARIATE F VALUES WITH    4 ,    22  DEGREES OF FREEDOM

                                .2046        .9563       2.2953

                                         SIGNIFICANCE LEVELS

                                .9314        .5477        .0908
```

```
                              DESIGN CONTRAST MATRIX = C
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0


                                     SUM OF PRODUCTS DUE TO HO =SH
                                  .5434722E-02   -.[illegible]076208E-04   -.2316918E-03
                                 -.5076208E-04    .736332E-06    .1600549E-05
                                 -.2316918E-03    .1600549E-05    .1306907E-04

                          UNIVARIATE F VALUES WITH    2 ,    22  DEGREES OF FREEDOM

                                .5764        .7967      86.1710

                                         SIGNIFICANCE LEVELS

                                .5750        .5329        .0001
```